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Role of ASCE in the Advancement of Computing in Civil Engineering

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Abstract: Computing has emerged as a major focus area in civil engineering, just as it has in other disciplines. This paper examines the role of the American Society of Civil Engineers (ASCE) in the advancement and development of this focus on computing in civil engineering. The paper documents the technical activities of ASCE that contributed to this evolution, particularly the committees of the Structural Division (now the Structural Engineering Institute) and the Technical Council on Computer Practices (now the Technical Council on Computing and Information Technology). Emphasis is placed on the initial activities and the current status of each group. A broad survey of ASCE activities that contribute to the dissemination of information on computing in civil engineering is presented. The role of ASCE publications in this effort is examined. The ASCE conferences and congresses on computing are documented and evaluated. Finally, observations are made about the society's overall impact on computing in civil engineering.

INTRODUCTION

Computers and computer-based tools have been an integral part of civil engineering for nearly 50 years. Much of today's civil engineering practice, particularly its reliance on rapid communication and interaction, analytical modeling and simulation, and geometric modeling and visualization, would be inconceivable without the aid of computing. A great deal of the computing underlying civil engineering practice and research has become so routine that it is simply not reported. Innovations, research results, and new developments based on computing capabilities tend to be reported in the conferences and journals of the appropriate subdiscipline within civil engineering most directly affected—structures, water resources, transportation, construction, and the like.

Paralleling and, to an extent, integrating the discipline-specified advances, there has emerged a broad, discipline-wide emphasis on the rapid evolution of computing, its supporting basic sciences, and its enabling information technologies. This emphasis is coupled with the exploration of potentials for improving civil engineering research, education, and practice by the exploitation of the emerging developments. In this paper, computing is used in its broadest sense to include computer-based communication; sharing and display of graphical, textual, and symbolic information; and calculation of numeric data. Computing thus defined affects every sphere of human endeavor. This paper specifically addresses computing in civil engineering.

The paper provides a compilation and review of a portion of the historical record of computing in civil engineering. This historic review is not meant to be complete and comprehensive. Rather, it is intended to sketch the evolution of those aspects of computing in civil engineering that have shaped today's roles and perceptions. The review is highly idiosyncratic, reflecting the writers' experiences, or, rather, their memory of those experiences, supplemented with material from the writers' files and contributions from colleagues. Furthermore, the review concentrates largely on the role of the American Society of Civil Engineers (ASCE) and its technical activities, conferences, and publications as a window on the evolution of the profession's practical, educational, and research activities in computing, rather than on the activities themselves.

The paper includes some new compilations of data on computing in civil engineering. It also summarizes and refers to other resources where more complete compilations of information already exist. Thus, it is intended to serve as a starting point for understanding the evolution of computing in civil engineering.

The activities and events described were the result of the work of many ASCE members. The writers wish that they had the space to acknowledge the contributions of all of these dedicated volunteers, but due to space limitations, they had to restrict themselves to recognizing only the most salient participants. The writers apologize in advance to those whose work could not be individually recognized.

ORGANIZATION OF PAPER

This section provides a brief introduction to the organization of the paper. The ''Early History of Computing in Civil Engineering'' section discusses the first steps in the introduction of computing into the civil engineering profession. The section describes the earliest civil engineering computing applications and identifies early difficulties and inhibitions to computing. The emergence and subsequent disappearance of user groups are described.

ASCE, the leading professional society of civil engineers, has played a significant role in the evolution of computing in

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civil engineering. This section examines what that role has been and what it is today. It identifies those ASCE activities that have had the most significant role in shaping computing and its use in civil engineering.

The ASCE *Journal of Technical Topics* (*JTT*) was one of the earlier journals to focus on computing in civil engineering. It was followed by the ASCE *Journal of Computing in Civil Engineering* (*JCCE*). The ''Publications'' section examines what has been published in these and other related journals. Some trends are identified and the more recent shifts in computing in civil engineering directions are identified. Other society publications are examined as well. The ''Summary and Observations'' section provides a synthesis of ideas and frames a window on the profession's use of computing and ASCE's overall impact on it.

EARLY HISTORY OF COMPUTING IN CIVIL ENGINEERING

Civil engineers began to use computers quite early. The two major impetuses for the introduction of computing in the 1950s and 1960s were, first, the defense and space programs and, second, the interstate highway system. Defense and space efforts required a whole new range of structural response modeling capabilities, while the vast interstate construction program required extensive design calculations at an enormous scale. Without a doubt, the single most successful civil engineering application of the early decades was the earthwork quantity (''cut-and-fill'') calculation program, churning out daily earthwork volumes for miles and miles of highways without having to draw and measure by planimeter the cross sections at every station. Optimization, in the sense of balanced cut and fill, became a practical reality by rerunning the calculations with changed grade elevations. The program further increased its usefulness, thus establishing the principle of capturing data at the source, when it began to be used not just for design (''estimated quantities''), but also for computing payments to contractors (''final quantities'') using the original ground data in conjunction with the final survey results.

The first computers acquired by engineering organizations, whether public agencies or private consulting and construction firms, came with some rudimentary programming tools—either native machine or assembly languages or not much more effective interpreted systems—and essentially no software. Thus, civil engineering organizations faced the daunting task of programming all the applications they needed.

Not surprisingly, user groups were quickly formed in order to share development efforts as well as to provide a united voice to the hardware vendors, particularly in clamoring for better software development tools. User groups tended to cluster around particular brands of computers, such as the Bendix G-15, the LGP30, and the IBM 650 and 1620 (all long ago consigned to their well-deserved trash piles). User groups sharing application interests began exchanging programs, tentatively and haphazardly at first, becoming better organized as time progressed, with coordinated planning, explicit development responsibilities, and elaborate accounting schemes for credits earned by submitting programs.

The IBM 1130, introduced around 1960 with the first practical FORTRAN compiler for small computers, became popular with civil engineering firms, and eventually the 1130 Users' Group, renamed Civil Engineering Program Applications (CEPA) (formed in 1965; the acronym was retained after the group was incorporated as the Society for Computer Applications in Engineering, Planning, and Architecture), became the preeminent civil engineering user organization (Civil 1966). In response to CEPA demands for a structural analysis tool, IBM provided a version of STRESS (Fenves et al. 1964, 1965) for the 1130. A second user group, the Highway Engineering Exchange Program, attracted the state transportation departments as well as their consultants. Many firms belonged to both groups. Somewhat later, the Integrated Civil Engineering System (ICES) (Roos 1966, 1967) User Group (IUG) became another user organization, notable in that it was concerned not with program development, but with the maintenance and use of ICES and its constituent programs, particularly STRUDL (Logcher et al. 1965), an outgrowth of STRESS, and COGO (Miller 1961; Roos and Miller 1964).

Eventually, professional issues related to the cost of computer program development, changing policies for computer use, and legal responsibilities began to dominate discussions at user group meetings. CEPA and similar groups felt that they needed representation at a higher professional level than that provided by their separate organizations. As discussed below, CEPA members were subsequently influential in directing ASCE into activities dealing with professional practice.

As computing in civil engineering practice increasingly moved away from in-house software development toward acquired third-party software, the role of user groups diminished substantially. In retrospect, it is difficult to determine how effective the actual program exchange function of these organizations was. Essentially all programs acquired from external sources had to be modified to some degree to reflect local practices. Suites of interrelated programs developed by a number of organizations did not mesh as well as planned. The primary intangible benefit of membership in the user groups turned out to be the networking the groups provided, binding together a collection of civil engineering computing professionals who were aware of the pioneering work they were doing.

ASCE

The divisions within ASCE that have been the most active in computing in civil engineering are the Structural Division and the Technical Council on Computing and Information Technology (TCCIT). These are discussed in detail in the following sections. Additionally, the current activities of all institutes, divisions, and councils active in computing are discussed.

Structural Division

Initial Committee Activities

The Structural Division's Committee on Electronic Computation was formed in the fall of 1957. Its first chairman was Dr. Nathan M. Newmark, head of the Department of Civil Engineering at the University of Illinois, a pioneering researcher and educator in structural engineering. The contact member from the Executive Committee of the division was Dr. Elmer Timby, a distinguished educator and consultant. It undoubtedly required the prestige of these two gentlemen to convince the division to establish a committee devoted to a device that was then still considered largely a laboratory curiosity. In the initial round of correspondence about potential committee activities, one member suggested the task of ''keeping a record of civil engineers in this country who are actively doing work in this field of electronic computation.'' Had such a record been implemented, it would have contained a few hundred entries, at most. Fenves, then a graduate student and instructor at the University of Illinois, was made secretary of the committee.

The initial subcommittees established by the Committee on Electronic Computation were as follows:

- Programming and Coding
- Mathematical Methods

TABLE 1. Conferences on Electronic Computation and Analysis and Computation

Number	Date	Location	Document	Editor(s)	Library number	International Standard Book Number
1	11/20–11/21/58	Kansas City, Mo.	—	—	—	—
2	9/8–9/9/60	Pittsburgh	—	—	—	—
3	6/19–6/21/63	Boulder, Colo.	(89)ST4,8/63	—	—	—
4	9/7–9/9/66	Los Angeles	(92)ST6,12/66	—	—	—
5	8/31–9/2/70	Lafayette, La.	(97)ST1,1/71	—	—	—
6	8/7–8/9/74	Atlanta	(101)ST4,4/74	—	—	—
7	8/6–8/8/79	St. Louis	—	—	—	—
8	2/21–2/23/83	Houston	—	James K. Nelson Jr.	59-65010	0-87262-351-3
9	2/23–2/26/86	Birmingham, Ala.	—	Kenneth M. Will	85-73831	0-87262-512-5
10	4/29–5/1/91	Indianapolis	—	Oktay Ural and Ton-Lo Wang	91-12684	0-87262-802-7
11	4/24–4/28/94	Atlanta	—	Franklin Y. Cheng	94-7104	0-87262-974-0
12	4/15–4/18/96	Chicago	—	Franklin Y. Cheng	96-11789	0-7844-0163-2
13	7/19–7/23/98	San Francisco	—	N. K. Srivastava	—	0-08-042845-2
14	2000	Philadelphia	—	—	—	—

Note: Dashes indicated unavailable information. All entries in the Document column represent conference proceedings except for four, which were published in the journals noted. Library number refers to the Library of Congress card catalog number. The first 10 conferences are referred to as Conferences on Electric Computation. Presently, and including 11, 12, 13, and 14, the conferences are referred to as Conferences on Analysis and Computation.

- Data Processing
- Current Progress and Planning
- Publications and Technical Programs

The first subcommittee eventually produced a series of manuals (with the first manual starting with machine language programming, of course, before proceeding to index registers), and the second, a number of annotated bibliographies, comparative book reviews, and program feature comparisons. In very short order, however, the Publications and Technical Programs Subcommittee became the primary focus of the committee, starting with the organization of the first session on computing at the February 1958 ASCE convention in Chicago. Dr. Elvind Hognestad, the Technical Program Committee chairman for the convention, asked the committee to provide ''a broad, simple, and informative subject presentation designed to be a 'first meeting' of the civil engineers of the audience with a new tool, the digital computer, which has the future potentiality of becoming as important to him as the slide rule.'' Fenves recalls the subcommittee rounding up the first three speakers, all Doctors of Philosophy (PhDs), and then working hard to find a fourth speaker who did not have an advanced degree, reflecting the subcommittee's strong belief that eventually it would not be necessary to have a PhD to be able to write a civil engineering application program.

Starting with Kansas City, Mo. in 1958, the committee organized a series of Conferences on Electronic Computation that have continued to this day (Table 1). Papers presented at the early conferences dealt with a great variety of analysis and design methods and programs; others addressed important issues of the day, such as analyzing very large structures on computers with 1–2 kilobyte words of memory and setting up early users' groups. Many other papers had impacts that are still felt today—the first matrix and finite-element analysis papers by Ray Clough (Clough 1958, 1960), the first consistent mass matrix paper by John Archer (Archer 1963), and others. The successive conference technical program committees exercised stringent quality control on the papers accepted. As an example, following C. L. Miller's paper on ''Man-Machine Communication in Civil Engineering'' at the Third Conference on Electronic Computation (Miller 1963) (apologies for the gender insensitivity of the time), papers describing programs that depended on users providing numeric codes for selecting program options were summarily rejected.

As time progressed, the committee attempted to address a range of issues broader than structural analysis and design. A subcommittee on professional problems was formed in 1967, and one on interdisciplinary activities was formed in 1970. Such activities were reviewed as exceeding the scope of the Structural Division within ASCE, and some had to be curtailed or eliminated at the request of the division's Executive Committee. As a result, some committee members began to look for alternate means of action within the society's framework.

In retrospect, from the mid-1950s to the mid-1970s, the Structural Division's Committee on Electronic Computation, chaired in succession by Nathan M. Newmark, Sidney Shore, Robert E. Fulton, and Donald McDonald, reflected quite accurately the developments of computing as they related to the technical aspects of structural engineering. Its conference proceedings and other publications showed the profession's response to the rapid, if not revolutionary, changes in support technologies such as programming languages, hardware and communication technologies, new application areas such as computer-aided design and computer graphics, and in research leading to new modeling and analysis capabilities. The committee's position within the ASCE organizational structure made it unsuited to address professional issues transcending structural engineering and affecting a larger proportion of the society's members.

Current Committee Activities

The Structural Division has since evolved into the Structural Engineering Institute. The Committee on Electronic Computation has continued to function to this day. Following the 10th Conference on Electronic Computation in 1991, the committee was renamed the Committee on Analysis and Computation in 1992. Its activities are summarized in a later section.

Over a span of 33 years, from 1958 to 1991, the Structural Division sponsored 10 Conferences on Electronic Computation (Table 1), averaging one approximately every three years. The third, fourth, fifth, and sixth conferences were republished as special issues of the *Journal of the Structural Division*. The 11th–14th Conferences on Analysis and Computation (sponsored by the Structural Engineering Institute) have been offered on a two-year cycle. The primary focus of these conferences is on computing in structural engineering.

Other Divisions

Initial Committee Activities

Progressions very similar to that of the Structural Division took place in other divisions. Specifically, by the late 1960s

the Geotechnical and Hydraulics Divisions both had technical committees similar in scope to the Committee on Electronic Computation of the Structural Division, although with less aggressive schedules of publications and specialty conferences. Contact among these groups across divisions was either through personal contacts or through organizations external to ASCE.

Current Committee Activities

Today, ASCE members are involved in computing through committee activities in a number of divisions. The following is a list of the ASCE committees specifically involved in computing (ASCE 2000), and their purposes.

1. Urban Transport Division, Computing in Transportation Committee. Its purpose is to facilitate the dissemination of information on new developments in computing for planning, design, operations, and management of urban transportation systems. The committee will encourage education and research necessary to advance computing applications in academia and practice.
2. Geo Institute, Computer Applications and Numerical Methods Committee. Its purpose is to serve the geo-profession areas of general computing use, including (1) software availability; (2) information technology; (3) numerical methods; and (4) general computing issues in professional practice. The committee provides support in these areas, both in leading roles and in cooperation with other technical committees and organizations.
3. Construction Division, Computing in Construction Committee. Its purpose is to simulate and influence the effective application of computer technology in construction.
4. Geomatics Division, Geographic Information Systems Committee. Its purpose is to serve as a resource to the profession in providing recommended guidelines for the development and selection of processes, procedures, techniques, and technologies associated with the collection, management, dissemination, and utilization of spatially related data; to identify and formulate the responsibility and contribution of civil engineering to integrated geographic information systems; to foster studies, research, and development; to develop and maintain appropriate technical standards and procedures; and to provide a focal point for interdivisional and interdisciplinary cooperation.
5. Structural Engineering Institute, Analysis and Computation Committee. Its purpose is to report, encourage the development of, and evaluate innovative methods of structural analysis; to foster the use of digital computer and other modern computing devices to obtain more effective analyses and improved designs; to encourage the development and reporting of innovations in the use of computers that may have practical significance; and to report on professional problems involving the multidisciplinary use of computers.
6. Structural Engineering Institute, Emerging Computing Technology Committee. Its purpose is to provide a mechanism by which various emerging computing technologies that may be applicable to some part of the structural engineering process can be identified and brought to the attention of the structural engineering community. These technologies include parallel and distributed computing, databases and information systems, Web-based and collaboration technologies, artificial intelligence, field based computing, and automation.

Research Council on Computer Practices

In 1970, a group of CEPA members who were also members of ASCE petitioned the society ''to appoint a coordinating council to deal with the legal, professional, and educational aspects of computer use, cutting across the technical divisions of ASCE.'' The initial petition brought the CEPA group in contact with like-minded people in the Structural and Geotechnical Divisions, and eventually led to the establishment of the Technical Council on Computer Practices (TCCP) via the short-lived Research Council on Computer Practices.

At the time the CEPA petition was made, technical councils were viewed within ASCE as proving grounds for fledgling divisions. The society had never before received a petition for a council that clearly stated that the proposed council had no intention of every becoming a division. As a result, the CEPA petition was denied. However, since research was one potential activity of such an eventual council, and since the Committee on Research was willing to act as a sponsor, the petition was changed to that for a Research Council on Computer Practices. The Task Committee on Computer Application Research of the Committee on Research was charged with organizing the research council and clarifying its relationship to an eventual council with broader goals. At its first meeting, the task committee resolved that ''this group intends to be the focal point in studying and pursuing the establishment of a Computer Practices Council.''

The Research Council on Computer Practices was authorized in 1972, with Elias C. Tonias, a consulting engineer—later a software developer—and CEPA member, as chair and Fenves as vice-chair. The Research Council proceeded to define the scope of the council-to-be in the following areas:

- Coordination within ASCE among the computing-related activities of the divisions
- Coordination outside ASCE with professional and users groups
- Education
- Professional practice
- Research

The aspects of professional practice included

- Computer pricing policies
- Computer facility organization and management
- Credibility and legal aspects of computer-aided design
- Software development costs and recovery procedures
- Job description and salary structure
- Legal and professional aspects of program sharing

This latter list makes clear the ambitious scope of professional practice issues that awaited the attention of the proposed council-to-be, quite distinct from the technical issues addressed by committees of the technical divisions. The Research Council on Computer Practices was abolished in 1973 as soon as the Technical Council on Computer Practices was authorized.

Technical Council on Computer Practices

Initial Committee Activities

As stated above, the first petition for a Technical Council on Computer Practices was denied because it was too broad in scope and cut across the traditional boundaries of the technical divisions. Coincidentally, while the second petition was being circulated in draft form, the ASCE Technical Activities Council (TAC), which oversees the divisions, was performing its own major restructuring study. The study group, chaired by Dr. Albert D. M. Lewis, professor of structural engineering at

Purdue University, and considering a ''matrix management'' structure, with divisions representing the ''depth'' dimension and some other organizational form representing the ''breadth'' dimension. The draft petition was embraced by the restructuring study group, which recommended ''technical council'' as the designation of the groups dealing with the breadth dimension.

The Technical Council of Computer Practices was authorized on January 30, 1973, as the first council under the new TAC organization. Subsequently, four other technical councils were formed—Codes and Standards, Lifeline Earthquake Engineering, Research, and Cold Regions. TCCP's objectives were ''to establish the means by which the civil engineering profession will be able to properly utilize the impact of the electronic computer and its related software in civil engineering practice, research, and education.'' The first 12 TCCP chairs were Robert L. Schiffman, Elias C. Tonias, Robert C. Y. Young, Augustine J. Fredrich, Norman R. Grieve, Steven J. Fenves, Vincent J. Vitagliano, Charles V. Smith, J. Crozier Brown, Charles Hodge, Morton B. Lipetz, and Richard L. Bland.

Five sets of early activities of TCCP are worth singling out. First, the Computer Practices Committee (CPC) produced an ASCE manual on computer pricing (ASCE 1973; Grieve 1976) and a number of reports on professional issues. Building on activities started in 1971, CPC cooperated with CEPA and later with IUG on the following three projects:

- Sponsoring a National Science Foundation (NSF)-funded Special Workshop on Engineering Software Coordination (1971) (Schiffman 1972a,b,c)
- Conducting an NSF-funded study entitled ''Definition of a National Effort to Promote Effective Application of Computer Software in the Practice of Civil Engineering and Building Construction'' (1973–76) (Civil 1975a,b; McGrory et al. 1975)
- Incorporating the National Institute for Computers in Engineering ''to provide an information service which will assist in promoting the effective use of computers and software as tools of the practicing engineer'' (1980–82) (Beck (1981)

The latter effort, important as it was for its time, came to naught with the advent of the personal computer and the subsequent blossoming of a competitive free-enterprise market in engineering software.

Second, starting with the First Conference on Computing in Civil Engineering at Atlanta in June 1978 (organized by Lipetz, Vitagliano, and Leroy Z. Emkin), the Committee on Coordination Outside ASCE (COCOA) became the organizer of national conferences and later congresses on computing in civil engineering. The first three conferences were organized in conjunction and cooperation with CEPA and the ICES User Group.

Third, COCOA organized the first international conference, while the following three were organized by other groups. Eventually, COCOA took over the organization of the fifth international conference and became instrumental in forming an organization that would oversee subsequent international conferences. That organization, the International Society for Computing in Civil and Structural Engineering (ISCCSE), came into being in 1993 and was formally ratified in 1995. All international conferences since that date have been conducted with the auspices of ISCCSE.

Over a span of 22 years, from 1978 to 2000, a total of 21 national and international conferences and congresses were sponsored. These conferences covered the entire range of computing topics throughout civil engineering. At a number of conferences, entire tracks of sessions were devoted to special topics and were separately identified as symposia. Admittedly, at later conferences and congresses, the coverage of the computing practices track has often not been as extensive as that of the academically oriented research track, and the two tracks have not always been well integrated. Nevertheless, these conferences and congresses have become one of the preeminent media for the exchange of information on the rapidly evolving aspects of computing in civil engineering. Details regarding the national and international conferences and congresses are presented in Tables 2–4.

Fourth, the Publications Committee undertook an aggressive publication schedule from the start, initially publishing in the *Journal of the Technical Councils*, then in the *Journal of Technical Topics*, and eventually in the *Journal of Computing in*

TABLE 2. National Conferences on Computing in Civil Engineering

Number	Date	Location	Editor(s)	Library number	International Standard Book Number
1	6/26–6/29/78	Atlanta	Morton B. Lipetz and Leroy Z. Emkin	—	—
2	6/9–6/13/80	Baltimore	David R. Schelling	80-66141	0-87262-246-0
3	4/2–4/6/84	San Diego	Charles S. Hodge	80-66141	0-87262-396-3
4	10/27–10/31/86	Boston	W. Tracy Lenocker	86-25911	0-87262-569-9
5	3/29–3/31/88	Alexandria, Va.	Kenneth M. Will	88-3771	0-87262-635-0
6	9/11–9/13/89	Atlanta	Thomas O. Barnwell Jr.	89-37697	0-87262-722-5
7	5/6–5/8/91	Washington, D.C.	Louis F. Cohn and William J. Rasdorf	91-12813	0-87262-803-5
8	6/7–6/9/92	Dallas	Barry J. Goodno and Jeff R. Wright	92-13050	0-87262-869-8

Note: Dashes indicate unavailable information. Library number refers to the Library of Congress card catalog number.

TABLE 3. National Congresses on Computing in Civil Engineering

Number	Date	Location	Editor(s)	Library number	International Standard Book Number
1	6/20–6/22/94	Washington, D.C.	Khalil Khozemieh	94-19972	0-7844-0026-1
2	6/5–6/8/95	Atlanta	J. P. Mohsen	95-15012	0-7844-0088-1
3	6/17–6/19/96	Anaheim, Calif.	Jorge Venegas and Paul Chinowsky	96-19480	0-7844-0182-9
4	6/16–6/18/97	Philadelphia	Teresa M. Adams	—	0-784-0250-7
5	10/18–10/21/98	Boston	Kevin C. P. Wang	—	0-784-0381-3

Note: Dashes indicate unavailable information. Library number refers to the Library of Congress card catalog number.

TABLE 4. International Conferences on Computing in Civil Engineering

Number	Date	Location	Country	Library number	International Standard Book Number
1	5/12–5/14/81	New York	United States	81-66346	0-87262-270-3
2	1985	Hangzhou, Zhejiang	China	4950-61[a]	0-444-99560-9
3	8/10–8/12/88	Vancouver	Canada	—	—
4	1991	Tokyo	Japan	—	—
5	6/1–6/9/93	Anaheim, Calif.	United States	93-17524	0-87262-915-5
6	1995	Berlin	Germany	—	90 5410 556 9
7	1997	Seoul	Korea	—	—
8	8/14–8/16/00	Stanford, Calif.	United States	—	0-7844-0513-1

Note: Dashes indicate unavailable information. Library number refers to the Library of Congress card catalog number.
[a]Science Press book number.

Civil Engineering. These activities are detailed in forthcoming sections. Fifth, the State of Computer Practices (SOCP) Committee responded to the perceived lack of information about practice-oriented information on computing available to ASCE members by launching the *CE Computing Review* newsletter, described in a later section.

Current Committee Activities

In 1997, the TCCP officially became the TCCIT. Its committees, and their purpose, as stated in the official ASCE register, are as follows (ASCE 2000).

1. Education—to study and promote educational uses of computers in the field of civil engineering; to promote the exchange of information regarding computer methods; to recommend those computer-related activities that promote educational objectives of colleges and universities
2. Publications—to administer the solicitation, review, and editing of manuscripts submitted for publication in the *JCCE* (The publications section discusses journals in greater detail.)
3. Imaging Technologies—to coordinate and promote the exchange of technical information about current and emerging imaging technologies and their application to civil engineering problems and projects
4. Intelligent Computing—to gather, maintain, and disseminate information on the application of expert systems and artificial intelligence to civil engineering, and to keep the society membership aware of developments in this rapidly growing field
5. State of Computer Practices—to gather, maintain, and disseminate information on existing and new developments in computer technology as it relates to civil engineering, and to promote an understanding within the engineering community of the benefits and limitations of that technology
6. Database and Information Management—to increase the appropriate use of databases and information management technologies in civil engineering teaching and practice (Included in the committee scope are the representation, management, storage, and retrieval of civil engineering information, product and process modeling, data/object/knowledge repositories and interoperability standards, and information infrastructure issues.)
7. Coordination of Computing Activities—to promote computer-related activities through coordination with groups internal and external to ASCE, including the presentation of specialty conferences and joint meetings with other organizations

Activities undertaken by these committees vary widely, and include committee meetings, international meetings, and interorganizational meetings; surveys; workshops; special issues and sections of the journal; conferences and conference sessions, tracks, and panels; as well as special publications and manuals.

Education Surveys

Adequate computing resources, expertise in the teaching of computing, and computing requirements in the curriculum have been engineering education concerns of both the academic community and the professional community. To a large extent, the first two of these have been ameliorated over time. The third, however, still presents a dilemma to engineering education. To better understand these concerns and the steps to be taken to overcome them, the TCCP undertook a series of computing surveys in 1986, 1989, and 1995. Consideration is currently being given to a follow-up survey in 2001.

In 1986, the Education Committee of the TCCP conducted a survey to determine the availability of computing resources in civil engineering departments and to determine the attitude of faculty (and professionals) toward education in computing in civil engineering. The following specific areas that needed exposure were identified by the survey:

1. Technology of computers
2. Computers as problem-solving tools
3. Computers as engineering simulators to assist in design

In 1987, TCCP formed a task committee to conduct a second survey to assess the status of computing in the civil engineering curriculum and to determine how to address these key areas. The task committee conducted the survey, analyzed and presented the results, suggested three different scenarios for incorporating problem-solving computing tools and concepts into the curriculum, and enumerated lists of pros and cons for each scenario. The results of the work were published in Law et al. (1989, 1990a,b), and were distributed widely to engineering faculty. Today they serve as a benchmark from which we can measure progress, reassess needs, and plan for the continued future roles of ASCE in computing in civil engineering (O'Neill et al. 1996a,b).

In 1995, the TCCP Education Committee again conducted a survey, aimed at both educators and practitioners, to determine their perspectives on the then-current role of computing in civil engineering. Because of the steady improvements and advances in computer technology, the committee made the case that surveys must be repeated on a regular basis to ensure that the computing needs of the profession are being properly defined and met, and that curriculum changes can be made when appropriate (O'Neill et al. 1996a,b).

The results of the 1995 practitioners' survey were surprisingly close to those of the 1989 survey, with the seven highest ranked items from 1989 (computer-aided design and drafting,

spreadsheets, databases, programming, graphics, word processing, and expert systems) appearing in the list of nine ranked items in 1995. The new survey also identified the growing importance of the Internet by including communications in its top nine items, whereas this item was ranked 11th in 1989 (O'Neill et al. 1996b). The results of the 1995 educators' survey were also close to those of the 1989 survey, with six of the eight highest ranked items from 1989 (spreadsheets, word processing, computer-aided design, programming, databases, and expert systems) appearing in the list of nine ranked items in 1995. There is also close agreement between the practitioner and academic surveys, indicating broad agreement on computing skill needs.

However, the 1995 survey clearly indicated that academicians had still not reached a consensus on what to teach with respect to a programming language course (O'Neill et al. 1996a). It was also observed that there was no consensus definition for computer fluency, a constantly moving target. Finally, the results of the survey indicated a strong appreciation for advances in information technology (communications and the Internet), as well as for the use of computing to assist students in communicating their ideas (equation solvers and presentation software) (O'Neill et al. 1996a).

PUBLICATIONS

A number of ASCE publications have contributed to the advancement of computing in civil engineering. These include its archival journals, special journal issues, conference proceedings, special publications, and textbooks. Some of its conventional publications, such as *ASCE Magazine* and *ASCE News*, publish feature articles on computing in civil engineering. These and other publications are described in this section.

Journal of the Technical Councils (*JTC*) and *Journal of Technical Topics*

When the Technical Council on Computer Practices was established in 1973, it had no immediate outlet for information dissemination through publications. For the 14 years between 1973 and 1987, the Publications Committee of the TCCP worked first through the *JTC* and then through the *JTT* to publish research findings and results.

In 1977, ASCE first published the *JCT* for the purpose of presenting the research activities of the Technical Councils. The *JTC* was published aperiodically from 1977 through 1982 (volume 103, number 1, December 1977 through volume 108, number 2, November 1982).

In 1983, the *JTC* of ASCE became the *JTT in Civil Engineering*. It was then published aperiodically through December of 1985 (volume 109, number 1, April 1983 through volume 111, number 1, December 1985). At that time, ASCE split the content of the *JTT*, establishing individual journals for each of the councils. Thus, the first issue of the *JCCE* appeared in 1987 (volume 1, number 1, January 1987), establishing the one primary archival publication of the TCCP.

Journal of Computing in Civil Engineering

The goal of the *JCCE* is to serve as an archival resource on computing in civil engineering for the professional and academic communities alike. It is published four times per year. The journal is abstracted in *ASCE Publications Information*, *Transactions of ASCE*, and in the Civil Engineering Database (online). It is indexed in the *Science Citation Index*. The journal covers new programming paradigms, information management systems, computer-aided engineering, intelligent computing, robotics and automation, and implementation strategies, as well as organizational impacts of and for computing resources (Rasdorf 1997).

Five-Year Review

All journals of ASCE are periodically evaluated for quality assurance. The *JCCE* underwent such a five-year review for the period of 1990–94 (Lakmazaheri and Rasdorf 1995, 1996). Although the review contained some of the elements of ''what the journals contain,'' its primary focus was on ''what people think of the journal.'' Insights into this question were gained through surveys of reviewers and authors, readers, and previous subscribers.

One of the findings of the five-year review was that the quality and scope of the journal were satisfactory. Another key finding was that the majority of those responding to the survey indicated that the *JCCE* did not influence their professional practice; these readers viewed the papers as too theoretical and suggested that the balance between research and practice was unsatisfactory. On the other hand, the needs of the academic community for a society publishing outlet in computing in civil engineering that would provide for a forum of information exchange on research and education topics, act as a resource and graduate teaching and research, and act as a filter to evaluate the degree of success, applicability, or utility of new computer science concepts and methodologies applied to civil engineering were perceived as being successfully met.

10-Year Analysis

A 1997 study provided a window on computing in civil engineering through the eyes of the *JCCE* (Lakmazaheri and Rasdorf 1997, 1998). That study conducted a detailed analysis of the journal over the 10-year period from 1987 to 1996, the first decade of publication.

The analysis was made to obtain a general perspective on the contributions and technical content of the journal. Its purpose was to help the computing in civil engineering community gain a better understanding of the nature and dynamics of (1) the research community and research areas and topics; and (2) the literature forming the knowledge infrastructure of the published work. The study tabulated authors and their contribution patterns; computing topics and civil engineering subdisciplines covered; and references cited, categorized (journals, conferences, reports, and theses), and their sources tabulated.

This study resulted in a valuable compilation of information. The study did not draw conclusions, but it provided a wealth of information regarding the publication of knowledge about computing in civil engineering. The report highlighted the significant role of ASCE in the advancement of computing in civil engineering through the *JCCE*.

CE Computing Review

By 1989, the TCCIT's SOCP Committee was increasingly concerned about how to get information about practice-related computing in civil engineering to ASCE's membership. At about the same time, the society's Publications Department was pursuing several options for creating new breeds of periodicals, including discipline-specific newsletters. SOCP agreed that a newsletter would fit its goals, and in June of 1989, the first monthly issue of *CE Computing Review* was published. *CE Computing Review* was edited by a professional editor employed by the society's Publications Department. SOCP provided the majority of the newsletter's editorial board. Articles were submitted to the editor and, although often reviewed by the editorial board, the final decision on publication was made by the editor.

CE Computing Review's content explored several avenues, with emphasis on computer use by practicing civil engineers. There were several reviews of popular civil engineering soft-

ware products written by engineers who used the products. The newsletter also provided basic personal computer user topics; at the time, this was the only place that many ASCE members were exposed to such information. During the life of *CE Computing Review*, SOCP continued to provide technical assistance and aid to the editors in creating a popular periodical. Many of the articles written for the newsletter were authored by SOCP committee members. Two SOCP members, Tracy W. Lenocker and Charles S. Hodge, authored monthly columns for several years for the newsletter.

During its first three years, *CE Computing Review* was financially successful, in that its subscription fees offset the cost of the editor, publishing, and mailing. In the following two years, the newsletter did not break even and became a financial burden on ASCE. Its last issue was published in June of 1994.

Other ASCE Publications

ASCE journals have sponsored a number of special issues or sections directly or indirectly focused on computing in civil engineering. Table 5 provides a compilation of these, and identifies the theme, subject, or title of the special issue, as well as the journal sponsoring it. These special issues and sections provide insight into computing areas deemed to be timely and of interest to the readers of various civil engineering subdisciplines. There is emphasis on topics broadly grouped into artificial intelligence [expert systems, robotics, neural networks, and even intelligent vehicle highway systems (IVHS)] and information technology (databases, object-oriented systems, geographic information systems, and data, product, and process modeling).

Civil Engineering, ASCE's monthly magazine, devotes a full issue of feature articles to computing each year, usually in June. Individual articles in other issues, such as that by Dewberry (2000), focus on the application of computing or new automation technologies in the practice of civil engineering. Each issue of the magazine features a Software Reviews section and a Computing section that focuses on the Web, software, and hardware. As a service to ASCE members, each issue also contains a significant amount of advertisements related to computing in civil engineering.

ASCE sponsors a Web page. This site assists civil engineers by providing information of interest to the profession. Additionally, the site supports activities of the Publications Division through a database of publications information.

The Civil Engineering DataBase, a comprehensive electronic index that presently contains all articles published in all 29 ASCE journals from the present back to 1973, provides a variety of indexes and information access formats. Conference proceedings papers, ASCE Press books, standards, committee reports, manuals of practice, *Civil Engineering*, and *ASCE News* have also been added to the database. Finally, an active forward link to the actual text of the article has been added for all on-line journals.

Beginning in January of 1999, full text versions of all ASCE journals appeared on-line, providing direct access to the text of the articles. Furthermore, the ASCE references cited in an article point to their citation in the Civil Engineering DataBase. Thus, each article points to all of its ASCE references, and any ASCE journal reference (since January 1995) points to the actual text of the article it cites. ASCE also offers a Personal Journal, whereby a reader subscribes to a fixed number of articles per year, rather than to one or more entire journals, and may search the entire journals database and extract or download up to the specified number of articles from any of the journals.

On the horizon is the ''virtual journal.'' The virtual journal focuses on a timely topic of interest in a specialized area. An ASCE editor selects articles from all 29 journals that relate to the topic and synthesizes them into a virtual journal, which points to each article in its home journal.

SUMMARY AND OBSERVATIONS

In the first two decades of the ''computer era,'' emphasis on computing in civil engineering was dispersed between organizations outside ASCE, notably computer user groups, and committees within ASCE divisions that addressed computing as a component of the subdisciplines within each division's scope. Of these committees, the Committee on Electronic Computation of the Structural Division had the most ambitious program of publications and conferences. However, as modern methods of structural analysis became more general, much of the literature in the field moved out of ASCE publications into journals with a broader scope. Thus, ASCE publications did not, and could not, become the premier archival repository on, say, the finite-element method. Furthermore, the segmentation of ASCE into divisions precluded any organizational entity that could address computing issues across the breadth of the profession.

At the end of this formative period, the Technical Council on Computer Practices emerged in response to the need for addressing within ASCE a range of broad professional issues arising out of the increased use of computing. The TCCP also

TABLE 5. Journal Special Issues and Sections

Journal	Volume (issue)	Date	Category	Subject
JCEM	119(2)	June 1993	Issue	''Applications of Microcomputers and Workstations in Construction''
JTE	113(2)	March 1987	Section	''Use of Expert Systems in Transportation Engineering''
JTE	113(4)	July 1987	Issue	''Microcomputers in Transportation''
JTE	116(3)	May/June 1990	Section	''Robotics and Automatic Imaging in Transportation Engineering''
JTE	116(4)	July/August 1990	Section	''Intelligent Vehicle/Highway Systems''
JCCE	1(4)	October 1987	Issue	''Expert Systems in Civil Engineering''
JCCE	4(3)	July 1990	Section	''Computational Geometry''
JCCE	5(1)	January 1991	Section	''Expert Systems in Planning and Design''
JCCE	6(1)	January 1992	Issue	''Databases''
JCCE	6(3)	July 1992	Issue	''Object Oriented Systems''
JCCE	7(3)	July 1993	Issue	''Geographic Information Analysis''
JCCE	8(2)	April 1994	Issue	''Neural Networks''
JCCE	8(4)	October 1994	Issue	''European Computing''
JCCE	10(3)	July 1996	Section	''Data, Product, and Process Modeling''
JCCE	13(1)	January 1999	Issue	''Computing and Information Technology in AEC Education''
JCCE	13(2)	April 1999	Issue	''Imaging Technologies in Civil and Environmental Engineering''
JCCE	15(1)	January 2001	Issue	''Information Technology for Life Cycle Infrastructure Management''

Note: *JCEM = Journal of Construction Engineering and Management*, *JTE = Journal of Transportation Engineering*, and *JCCE = Journal of Computing in Civil Engineering.*

pointed the way for ASCE to form other councils dealing with cross-disciplinary issues. The TCCP, together with its successor, TCCIT, have satisfied the objectives of the initial petitioners, in at least two respects.

First, the TCCP provided the ASCE ''seal of approval'' on publications dealing with professional issues such as computer pricing policies at a time when such a seal was needed. Most of these issues have by now become so much a part of civil engineering business practices that the ASCE seal is no longer needed.

Second, the TCCP publications and proceedings of conferences and congresses have provided a forum for the discussion and dissemination of innovations in computing in civil engineering. The record is by no means perfect. As the surveys indicate, the practice-oriented segment of ASCE feels poorly served by the *JCCE*, but this is a perennial issue across all ASCE publications. The conference and congress proceedings have a larger contingent of practice-oriented material, but here too research themes predominate. This is not a bad thing by itself; after all, today's research is the seed of tomorrow's practice. What makes the situation in computing in civil engineering more precarious is the extremely rapid changes in computing and information technology (IT). Much of computing in civil engineering research is motivated by the perceived shortcomings in practice. However, with very few exceptions, the vast effort by the civil engineering industry organizations and software vendors has taken place with essentially no direct input from the research community. The best that can be said is that practice has benefited from some of the research explorations that have produced awareness and illustrations of new approaches.

In parallel with the TCCP, the institutes, divisions, and councils of ASCE have continued a deep involvement with computing in civil engineering, which now permeates every aspect of the profession. This frequently raises the question on where a new paper is to be published or the search for a prior paper initiated: Is the content more clearly identified by the kind of computing involved or with the subdiscipline specific phenomenon addressed? This overlap, and potential abuses of it, requires the vigilance of all journal editors and conference program chairpersons. Finally, ASCE as a whole has continued to adopt aspects of computing in civil engineering through its magazine and other IT initiatives.

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